

1           **METHOD AND SYSTEM FOR COMMUNICATING**  
2           **INFORMATION WITHIN A PHYSICAL LINK LAYER**

3  
4   This invention relates to the field of packet based  
5   communications systems.       More particularly, this  
6   invention relates to a method and apparatus that permits  
7   direct communication of information between elements  
8   within the physical link layer of a packet based  
9   communication system.

10  
11   **Background Art**

12  
13   A schematic representation of an Open Systems  
14   Interconnection (OSI) model 1 is presented in Figure 1.  
15   The OSI model 1 is a seven layer reference model  
16   recommended by the International Standards Organisation  
17   (ISO) to provide a logical structure for network  
18   operations protocol. Within the OSI model 1 a Physical  
19   Link Layer 2 is defined as the lowest layer and above  
20   this lies a Datalink Layer 3. The Datalink layer has  
21   several functions 3, but within a packet based  
22   communication system the Datalink layer 3 performs the  
23   task of encoding and decoding a data stream into discrete  
24   data packets.

1 The Physical Link Layer 2 is often conveniently  
2 subdivided into a Physical Coding Sub-layer (PCS) 4, a  
3 Physical Media Attachment (PMA) layer 5 and a Physical  
4 Media Device (PMD) layer 6. The PCS 4, further encodes  
5 the packet data suitable for transmission across the  
6 physical media. The PMA 5 provides an attachment layer  
7 between PCS 4 and the PMD 6. The PMD 6 is responsible  
8 for the physical transmission of the signal.

9

10 Figure 2 presents a schematic representation of a packet  
11 based communication system 7, as is known to those  
12 skilled in the art e.g. an Ethernet or a Fibre Channel  
13 systems. The packet based communication system 7 is  
14 shown in a simplified form so as to comprise a  
15 transmitter 8 that performs the tasks of the PMD layer 6  
16 and optionally also the PMA layer 5. The transmitter 8  
17 acts to convert the packet encoded electrical input  
18 signal "in" 9, produced within the higher Datalink layer  
19 3 and PCS layer 4, into a data packet signal 10 suitable  
20 for transmission through a propagation medium 11. In  
21 this example the data packets 10 comprise optical signals  
22 for transmission through an optical fibre. At the output  
23 of the propagation medium 11 is located a receiver 12.  
24 The receiver 12 is employed to detect the signals in a  
25 PMD layer 6 and PMA layer 5 device and convert them into  
26 an electrical output signal "out" 13 for packet de-coding  
27 within the PCS layer 4 and Datalink layer 3 of the packet  
28 based communication system 7.

29

30 Further detail of the transmission of a data stream,  
31 comprising a plurality of data packets 10, within the  
32 propagation medium 11 is shown in Figure 3. These  
33 schemes are employed by IEEE 802.3 Ethernet, ANSI Fibre  
34 Channel, OIF SPI and SFI Physical Link Layer Standards.

1 It is known to those skilled in the art that the data  
2 packets 10 are required to be dispersed with idle data  
3 fields 14 which are again produced within the Datalink  
4 layer 3 of the packet based communication system 7.

5

6 In particular, the data packets 10 are encoded so as to  
7 only contain certain data characters, and prohibit  
8 others, and are further delimited by special formatting  
9 characters that act to frame the data packets 10. The  
10 idle data field 14 contains other special and unique data  
11 characters that make them very distinct from the data  
12 packets 10. For example, in the Ethernet standard 802.3  
13 Clause 36, the idle data fields 14 comprise the comma  
14 character, alternatively called a K28.5 pattern, that has  
15 one unique 10-bit word pattern 1100000101. During the  
16 idle period no data is conveyed from the transmitter 8 to  
17 the receiver 12, the idle data fields 14 being required  
18 only to retain the link "up" status between the  
19 transmitter 8 and the receiver 12 so as to retain data  
20 clock synchronisation at the receiver 12.

21

22 Within the aforementioned packet based communications  
23 systems there is no facility, post packet encoding, for  
24 inserting or extracting information at the Physical Link  
25 Layer 2, within the PMA layer 5 or the PCS layer 4.  
26 Thus, once the electrical input signals "in" 9 have been  
27 encoded as packets within the standard Datalink layer 3  
28 or the PCS layer 4 there is no means within the prior art  
29 systems for exploiting the substantially unused idle data  
30 fields 14.

31

32 It is an object of an aspect of the present invention to  
33 provide a method and apparatus that permits direct  
34 communication of information between elements within the

1 physical link layer of a packet based communication  
2 system.

3

4 According to a first aspect of the present invention  
5 there is provided a method of communicating information  
6 within the physical link layer of a packet based  
7 communication system that comprises the steps of:

- 8 1) Employing a physical link layer transmitter to  
9 substitute an additional input data field within  
10 an idle data field of a data stream transmitted  
11 within the packet based communication system ; and
- 12 2) Employing a physical link layer receiver to  
13 extract the additional input data field without  
14 corrupting information contained within the data  
15 stream.

16

17 Preferably the step of substituting an additional input  
18 signal within an idle data field comprises the steps of:

- 19 1) Detecting one or more idle data field characters;  
20 and
- 21 2) Replacing the one or more idle field data  
22 characters with a physical link layer data  
23 character.

24

25 Optionally the one or more idle field data characters to  
26 be replaced are located within two or more of the idle  
27 data fields.

28

29 Preferably the step of extracting the additional input  
30 data field without corrupting information contained  
31 within the data stream comprises the steps of:

- 32 1) Detecting one or more physical link layer data  
33 characters; and

1           2) Extracting and replacing the one or more physical  
2           link layer data characters with idle field  
3           characters.

4

5   Preferably the step of replacing the one or more idle  
6   field data characters with the physical link layer data  
7   characters comprises replacing one or more idle field  
8   data characters with a start data insertion multiplexer  
9   character.

10

11   Preferably the step of replacing the one or more idle  
12   field data characters with the physical link layer data  
13   characters further comprises replacing one or more idle  
14   field data characters with a data control character.

15

16   Preferably the step of replacing the one or more idle  
17   field data characters with the physical link layer data  
18   characters comprises replacing one or more idle field  
19   data characters with an additional input data character.

20

21   Optionally the step of replacing one or more idle field  
22   data characters with the physical link layer data  
23   characters further comprises the step of replacing one or  
24   more idle field data characters with an end input data  
25   character.

26

27   Preferably the step of detecting the physical link layer  
28   data comprises activating a data extraction de-  
29   multiplexer when the receiver detects one or more start  
30   data insertion multiplexer characters.

31

32   According to a second aspect of the present invention  
33   there is provided a packet based communication system  
34   comprising one or more transmitters, one or more

1 transmission media and one or more receivers wherein at  
2 least one of the one or more transmitters comprises a  
3 data insertion multiplexer for generating and inserting  
4 physical link layer data, and at least one of the one or  
5 more receivers comprises a data extraction de-multiplexer  
6 for detecting and extracting the physical link layer  
7 data.

8

9

#### 10 **Brief Description of Drawings**

11

12 In the following detailed description of the preferred  
13 embodiments or mode, reference is made to the  
14 accompanying drawings, which form part hereof, and in  
15 which are shown, by way of illustration, specific  
16 embodiments in which the invention may be practised. It  
17 is to be understood that other embodiments may be  
18 utilised and structural changes may be made without  
19 departing from the scope of the present invention.

20

21 FIGURE 1 shows a schematic representation of a prior art  
22 Open Systems Interconnection (OSI) model;

23

24 FIGURE 2 shows a typical prior art packet based  
25 communications system at the physical link  
26 layer;

27

28 FIGURE 3 shows a typical data packet transmission within  
29 the communications system of Figure 2;

30

31 FIGURE 4 shows a packet based communications system at  
32 the physical link layer that employs the method  
33 and apparatus for inserting an additional field

1           in accordance with aspects of the present  
2           invention;

3

4   FIGURE 5 shows a schematic representation of the  
5           additional data field when inserted between two  
6           data packets by the packet based communications  
7           system of Figure 4;

8

9   FIGURE 6 shows details of a coding field of the  
10          additional data field of Figure 5;

11

12   FIGURE 7 shows a flow diagram of the method employed by  
13          a data insertion multiplexer of a transmitter  
14          of Figure 4, employed to insert the additional  
15          data field; and

16

17   FIGURE 8 shows a flow diagram of the method employed by  
18          a data extraction de-multiplexer of a receiver  
19          of Figure 4, employed to extract the additional  
20          data field.

21

22

### 23   Detailed Description

24

25   A packet based communications system 15 at the physical  
26   link layer that employs a method of inserting an  
27   additional field in accordance with an aspect of the  
28   present invention, is presented in Figure 4. The  
29   physical link layers of the packet based communications  
30   system 15 can be seen to comprise common elements with  
31   the prior art system shown in Figure 2, and described  
32   above, therefore for clarity purposes the same reference  
33   numerals are employed throughout, as appropriate.

34



1 The packet based communications system 15 can be seen to  
2 comprise a transmitter 8, a propagation medium 11 and a  
3 receiver 12. The form of the data packets 10 generated  
4 by the transmitter 8 are again controlled by an  
5 electrical input signal "in" 9 produced within the  
6 Datalink layer 3 before reaching the physical link layer  
7 of the packet based communication system 15. The  
8 receiver 12 again is employed to convert the detected  
9 data packets 15 into an electrical output signal "out" 13  
10 for use within the datalink layer 3 of the packet based  
11 communication system 15.

12

13 The transmitter 8 is partitioned into a data packet  
14 encoder source 16, a data insertion multiplexer element  
15 (MUX) 17 and an physical output stage 18. The signal  
16 transmitted via the propagation medium 11 is received at  
17 the receiver 12, which has been partitioned into an  
18 physical input stage 19, a data extraction de-multiplexer  
19 element (DEMUX) 20 and a data packet decoder 21. An  
20 additional input data "datin" 22 field can be inserted  
21 within the normal input signal "in" 9 by the MUX 17, as  
22 described below. The additional input data 22 can then  
23 be extracted by the DEMUX 20, so as to provide a "DatOut"  
24 23 signal in addition to the normal output signal "out"  
25 13, as described below.

26

27 Figure 5 shows an example additional input data "DatIn"  
28 22 field inserted between two data 10 of a transmitted  
29 signal. The additional input data "DatIn" 22 field is  
30 inserted by employing the MUX 17 to replace a portion of  
31 the idle data field 14 by swapping out individual idle  
32 field characters 24. In a reciprocal manner the  
33 additional output data "DatOut" 23 field is extracted by  
34 employing the DEMUX 20 to replace the additional input



1 data "DatIn" 22 field by swapping in individual idle  
2 field characters 24.

3

4 Figure 6 shows detail of a coding scheme employed within  
5 the additional input data "DatIn" 22 field so as to  
6 provide for its insertion and extraction. The coding  
7 field can be seen to comprise three distinct sub fields  
8 namely, a series Start Of MUX characters (SOM) 25,  
9 control characters CNT<sub>A</sub> and CNT<sub>B</sub> 26 or a plurality of data  
10 characters DAT<sub>1</sub> to DAT<sub>n</sub> 27.

11

12 Figure 7 presents a flow diagram of the method employed  
13 by the MUX 17 of the transmitter 8 when operating to  
14 insert the additional input data "DatIn" 22 field. In  
15 general the states are advanced and decisions are made on  
16 the arrival of each character from the data packet  
17 encoder source 16.

18

19 Transmitter START 28, SEND IDLE 29 and SEND SOM 30 stages  
20 are included and all correspond to the initial activation  
21 of the transmitter 8, as is known to those skilled in the  
22 art. In particular, the Transmitter START 28 stage is  
23 typically determined by a power on condition, an external  
24 reset, or a manual reset override. Following the  
25 Transmitter START 28 stage the MUX 17 inserts an initial  
26 sequence of idle field characters (not shown) into the  
27 data stream being sent to the channel receiver by  
28 employing the SEND IDLE 29 stage. The idle field  
29 characters are in a sufficient amount to allow data  
30 recovery synchronisation in the channel receiver as per  
31 an appropriate standard, and typically comprise a  
32 programmable quantity. After the initial idle sequence,  
33 SOM characters (not shown) are sent by the SEND SOM 30  
34 from the MUX 17. These SOM characters (not shown) are

1 employed to clearly indicate that additional input data  
2 is to be sent and are required to be easily  
3 distinguishable from the idle characters and the start of  
4 data packet characters. Again the actual number of SOM  
5 characters (not shown) sent is typically a user  
6 programmable quantity.

7  
8 The next stage involves the transmission of the normal  
9 data packets 10 by the MUX 17, as represented by a SEND  
10 NORM 31 stage. This continues until such time that START  
11 MUX 32 stage sets a YES branch that occurs when the MUX  
12 17 continuously detects idle characters 24. The  
13 particular number of idle characters required to set the  
14 YES branch is user programmable. The START MUX 32  
15 branches NO immediately on the next character, if a data  
16 packets 10 is detected in the data stream, regardless of  
17 whether the full additional input data "DatIn" 22 has  
18 been sent so preventing any corruption of the normal data  
19 packets 10.

20  
21 A SENT SOM ? 33 stage then branches YES only when a  
22 suitable, programmable, quantity of SOM characters 25  
23 have been sent. If a SENT SOM ? 33 NO condition occurs  
24 then an additional SOM character 25 is sent by a SEND SOM  
25 34 stage of the MUX 17. Following the SOM character 25  
26 being sent the state returns back to START MUX 32 and  
27 continues with the insertion of the additional input data  
28 "DatIn" 22 only if no non idle characters 24 are present  
29 in the data stream from the packet encoder 16.

30  
31 Next a SENT CNT ? 35 stage branches YES only when a  
32 suitable, programmable, quantity of CNT<sub>i</sub> characters 26  
33 have been sent. If a SENT CNT ? 35 NO condition occurs  
34 then an additional CNT<sub>i</sub> character 26 is sent by a SEND CNT

1 36 stage of the MUX 17. Following the CNT<sub>i</sub> character 26  
2 being sent the state returns back to START MUX 32 and  
3 continues with the insertion of the additional input data  
4 "DatIn" 22 only if no non idle characters 24 are present  
5 in the data stream from the packet encoder 16.

6  
7 A SENT DAT ? 37 stage then branches YES only when a  
8 suitable, programmable, quantity of DAT characters 27  
9 have been sent. If a SENT DAT ? 37 NO condition occurs  
10 then an additional DAT character 27 is sent by a SEND DAT  
11 38 stage of the MUX. Following a DAT character 27 being  
12 sent the state returns back to START MUX 32 and continues  
13 with the insertion of the additional input data "DatIn"  
14 22 only if no non idle characters 24 are present in the  
15 data stream from the packet encoder 16.

16  
17 Figure 8 presents a flow diagram of the method employed  
18 by the DEMUX 20 of the receiver 12 when operating to  
19 extract the additional input data "DatIn" 22 field so as  
20 to produce an additional output data "DatOut" 23 field.  
21 In general the states are advanced and decisions are made  
22 on the arrival of each character from the transmitter 8,  
23 via the propagation medium 11 and the input stage 19.

24  
25 The Receiver START 39 stage is entered on a power on  
26 condition, external reset, manual reset override,  
27 whenever there is a loss of data synchronisation, or when  
28 no signal is detected due to an interruption of the data  
29 link from the input stage, as is typical of those systems  
30 known in the prior art. Following the Receiver START 39  
31 stage a First DETECT SOM? 40 stage is entered on the  
32 arrival of the first character of the data stream. This  
33 stage branches YES only if a SOM character (not shown) is  
34 detected indicating that a transmitter 8 suitable for

1 generating additional input data "DatIn" 22 fields is  
2 present on the physical link layer 15. On a NO branch  
3 being outputted no additional input data "DatIn" 22  
4 characters are assumed to be capable of being  
5 transmitted, therefore a first SEND NORM 41 stage of the  
6 DEMUX 20 acts so as to pass data packets 10 through to  
7 the packet decoder 21 from the input stage 19.

8  
9 However, when a YES branch is outputted by the First  
10 DETECT SOM ? 40 Stage a First INSERT IDLE 42 stage then  
11 strips the SOM character (not shown) and replaces it with  
12 an Idle character 24 that is then sent by the DEMUX 20  
13 onto the packet decoder 21.

14  
15 A Second DETECT SOM ? 43 stage is then employed to detect  
16 the presence of subsequent SOM characters (not shown).  
17 On a YES branch being outputted from the Second DETECT  
18 SOM ? 43 stage a Second INSERT IDLE 44 stage then strips  
19 the SOM character 25 and replaces it with an Idle  
20 character 24 that is then sent by the DEMUX 20 to the  
21 data packet decoder 21. The DEMUX 20 state then returns  
22 to the Second DETECT SOM ? 43 stage. Thus, the SOM  
23 characters (not shown) are prevented from entering the  
24 data packet decoder 21, so as to avoid a potentially  
25 erroneous operation within it.

26  
27 On a NO branch being outputted from the Second DETECT SOM  
28 ? 43 stage a Second SEND NORM 45 stage of the DEMUX 20  
29 acts to pass the data packets 10 to the packet decoder 21  
30 in the normal manner. The DEMUX 20 then progresses to a  
31 DETECT MUX ? 46 stage that monitors the data stream  
32 searching for the presence of the additional input data  
33 "DatIn" 22 field. When no additional input data "DataIn"

1 22 field is detected the DEMUX 20 returns to the Second  
2 SEND NORM 45 stage.

3

4 However, when the DETECT MUX ? 46 stage branches YES the  
5 DEMUX 20 moves to a Third INSERT IDLE 47 stage that acts  
6 to extract a character from the additional input data  
7 "DatIn" 22 field send it on as required within the  
8 additional output data "DatOut" 23 field.  
9 Simultaneously, the Third INSERT IDLE 47 stage replaces  
10 the extracted character with an idle character 24 that is  
11 sent on to the packet decoder 21. The DEMUX 20 then  
12 returns to the DETECT MUX ? 46 stage and repeats the  
13 above process so as to sequentially remove and replace  
14 all of the SOM 25, Control 26 and Data 27 characters of  
15 the additional input data "DatIn" 22 field. Once  
16 completed the DETECT MUX ? 46 stage branches NO and so  
17 the DEMUX 20 returns to the Second SEND NORM Stage 45.

18

19 The above description describes a method wherein the  
20 complete additional input data "DatIn" 22 field is  
21 inserted within an idle data field 14 at the physical  
22 link layer of a packet based communications systems 15.  
23 If the idle data field is not large enough to contain the  
24 full additional input data "DatIn" 22 field then the  
25 insertion process is stopped and commences again from the  
26 start when the next available idle data field 24 is  
27 detected. It will be apparent to those skilled in the  
28 art that the method may easily modified so that separate  
29 parts of the additional input data "DatIn" 22 field may  
30 be transmitted within different idle data fields 24.  
31 This could be achieved by the insertion of one or more  
32 END characters within the additional input data "DatIn"  
33 22 field so that the receiver knows when a full  
34 additional input data "DatIn" 22 field has been



1 transmitted. Alternatively, this could also be achieved  
2 by the use of additional special character codes that  
3 specifically mark the additional input data 22 as an  
4 incomplete field.

5  
6 Further alternative embodiments that will be apparent to  
7 those skilled in the art include extending the described  
8 system to comprise more than one channel, two-way  
9 channels or multi-channel systems with additional input  
10 data "DatIn" 22 fields being exchanged between these  
11 channels.

12  
13 The described method may also be readily incorporated  
14 within a number of transmission media including, but not  
15 limited to, over air, optical fibre, printed circuit  
16 board or cable. Similarly different types of  
17 transmission signal formats may be employed including,  
18 but not limited to, analogue, digital, modulated, un-  
19 modulated, return to zero coding, non return to zero  
20 coding, encoded data, non encoded data, multi-level,  
21 binary, continuous or discontinuous, framed, burst or  
22 packet based or any combination of these.

23  
24 Different types of transmission techniques may also be  
25 employed including, but not limited to, electrical,  
26 electro-magnetic, magnetic or optical means.

27  
28 The described method relates to a communication system  
29 where only one transmitter and one receiver is used with  
30 one media channel. However, in alternative embodiments,  
31 transmission can be made from more than one transmitter  
32 sharing one or more media channels to one or more  
33 receivers. Furthermore the transmitter and the receiver  
34 are described as being two separate elements or



1 components of the system. However, in alternative  
2 embodiments, the transmitter and the receiver can be  
3 joined or part joined within the same combined element or  
4 component of the system, as relevant to multi-channel bi-  
5 directional applications. In yet further alternative  
6 embodiments the transmitter and/or the receiver can  
7 comprise a different combination of separate elements in  
8 a combination with less or additional elements so as  
9 could be viewed to act as a transmitter and or receiver,  
10 respectfully.

11

12 Further alternative embodiments to the communication  
13 system include the system comprising:

- 14 • additional filters, transducers, amplifiers,  
15 sensors or other elements or components between  
16 the transmitter and receiver.
- 17 • separate sections of media, separated by filters,  
18 transducers, sensors, transponders, transceivers,  
19 transmitters, receivers or other elements so as  
20 the break the media into one or more sections of  
21 not necessarily the same type of media.

22

23 Alternative embodiments for the transmission of data  
24 within the physical layer include no idle characters  
25 being employed either side of the additional input data  
26 "DatIn" fields. Other coding schemes and data structures  
27 can also be readily incorporated within the additional  
28 input data "DatIn" fields. In particular the CNT data  
29 can contain a unique physical port address identifying  
30 that physical device on the link layer. This can be  
31 used, for example, in links where a device is employed as  
32 a physical layer repeater. Each device can then be pre-  
33 assigned or dynamically assigned the unique identifier as  
34 appropriate.

1  
2 In a further embodiment of the above method it may be  
3 desirable not to extract the additional output data  
4 "DatOut" fields at the DEMUX but instead to employ this  
5 element to pass on or alternatively add additional data.  
6 This would be the case, for example, where the device is  
7 employed as a physical link layer repeater. This would  
8 allow for physical link information to permeate through  
9 the system to the channel final receiver. In this way  
10 the final receiver can gather all the additional input  
11 data "DatIn" fields on the link whilst each repeater in  
12 the link can also receiving its necessary physical link  
13 data. Such features can be added by having a suitable  
14 pass/block flag set in the control character CNT of the  
15 additional data field.

16  
17 In a bi-directional or multi-directional communications  
18 system embodiment the control character field CNT, or  
19 elsewhere within the additional mux data field, may  
20 contain link status flags. These flags can be used to  
21 arrange a handshaking protocol for establishing link-up  
22 status between all sets of transmitters and receivers  
23 before any data is transferred and providing  
24 acknowledgement of successful data transfer in  
25 conjunction with a suitable error detection scheme in the  
26 data such as cyclical redundancy checking (CRC).

27  
28 The above method provides a means for improving the  
29 efficiency of a packet based communications systems by  
30 exploiting existing relevant standards to transmit a  
31 quantity of additional data by encoding it within one of  
32 the existing fields of the defined packet structure.  
33 Such additional data can be used for any purpose as  
34 desired, but in the described embodiment the additional

1 data is required specifically for the physical link. The  
2 information includes transmitter and receiver physical  
3 parametrics and such information is employed in addition  
4 to any existing data provisioned within any known  
5 standard.

6  
7 The additional information is conveniently multiplexed  
8 within the physical link layer whilst being transparent  
9 to the normal packet based data. Employing this method  
10 puts no extra bandwidth requirement on the communications  
11 system. A significant benefit of multiplexing this data  
12 at the physical link layer itself is that it allows data  
13 to be added, extracted and stripped within the physical  
14 layer device at the point where the information is both  
15 available and required. This is architecturally  
16 efficient and leads to a performance, cost and size  
17 superior solution when compared to other conceivable  
18 alternatives.

19  
20 The foregoing description of the invention has been  
21 presented for purposes of illustration and description  
22 and is not intended to be exhaustive or to limit the  
23 invention to the precise form disclosed. The described  
24 embodiments were chosen and described in order to best  
25 explain the principles of the invention and its practical  
26 application to thereby enable others skilled in the art  
27 to best utilise the invention in various embodiments and  
28 with various modifications as are suited to the  
29 particular use contemplated. Therefore, further  
30 modifications or improvements may be incorporated without  
31 departing from the scope of the invention herein  
32 intended.